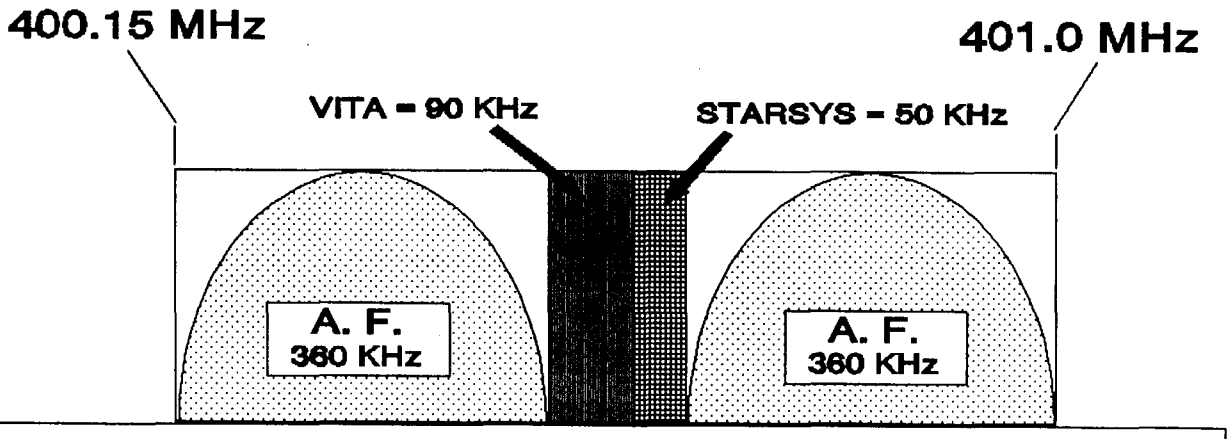
STARSYS
GLOBAL POSITIONING

400.15-401.0 MHz DOWNLINK BAND

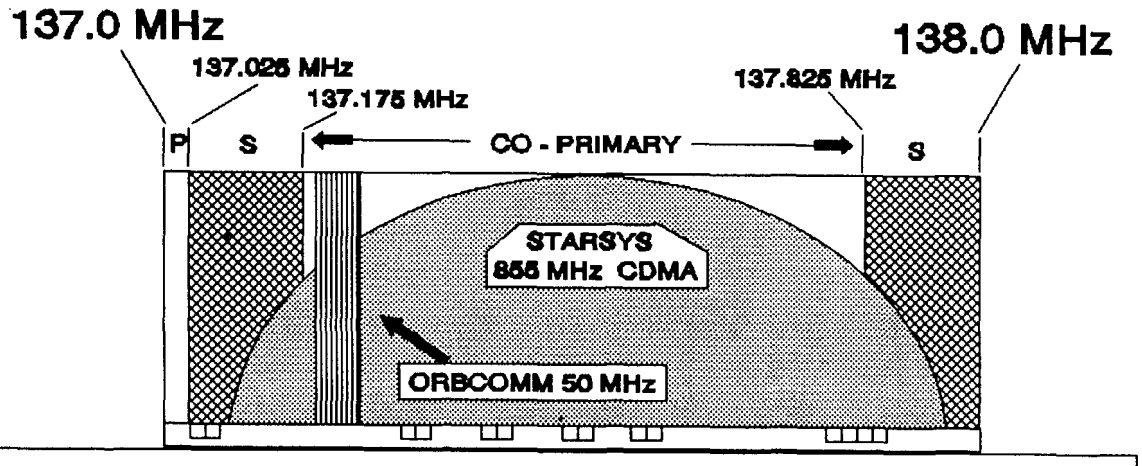


LEO MSS SHARING IN 401.15 - 401.0 MHz BAND

- VITA AND STARSYS LOCATION SUBJECT TO FINAL COORDINATION
- AIR FORCE DMSP SYSTEM = 710 KHz

STARSYS
GLOBAL POSITIONING

137-138 MHz DOWNLINK BAND



LEO MSS SHARING IN 137.0 - 138.0 MHz BAND

- STARSYS / ORBCOMM SHARING VIA DIRECTIONAL ANTENNAS, AND CROSS-POLARIZATION
- STARSYS SPREAD-SPECTRUM LIMITED TO 855 MHz DUE TO UPLINK WIDTH
- STARSYS IS SECONDARY IN BOTH AREAS

P = PRIMARY ALLOCATION S = SECONDARY ALLOCATION ▭ = METSAT.

SHARING PLAN SUMMARY

- ACCOMPLISHED: FREQUENCY SHARING PLAN FOR LITTLE LEO
- STARSYS COMPROMISES:
  - REDUCED BANDWIDTH FOR CDMA (855 KHz vs. 1.0 MHz)

    IMPACT: REDUCED DATA FLOW/CUSTOMERS
  - USE OF SECONDARY ALLOCATION

    IMPACT: POTENTIAL LOSS OF SPECTRUM
  - INCREASED COMPLEXITY OF SATELLITES AND MOBILE TERMINALS (ON-BOARD PROCESSING, TWO-BAND RECEIVERS)

    IMPACT: SIGNIFICANTLY MORE EXPENSIVE SYSTEM

STARSYS
GLOBAL POSITIONING

FUTURE SPECTRUM AVAILABILITY

- CURRENT: USING CURRENT PROPOSED JOINT SHARING PLAN

  CDMA: SHARE PROPOSED BANDWIDTHS

  FDMA: SHARE PROPOSED AND SPARE CHANNELS

  OTHER: 312-315 MHz & 387-390 MHz SECONDARY

  SPECTRUM REUSABLE AROUND THE GLOBE

- FUTURE APPLICANTS

  1997: TRANSIT FREQUENCIES

  2000: ADDED METSAT FREQUENCIES

  WARC: SUCCESS = ADDED SPECTRUM ALLOCATION

Orbital Communications Corporation

An QSC Company

ORBCOMM℠

FDMA Sharing Techniques for LEO MSS

August 24, 1992

"Vital Communications Absolutely Anyplace on Earth℠"

5000.CSR

FDMA Techniques for Shared Use of 137.0-138.0 MHz and 148.0 - 149.9 MHz Bands

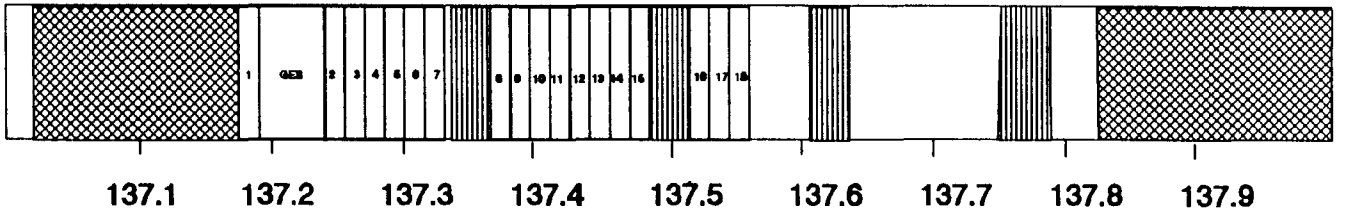
Orbital Communications Corporation
An OSC Company

- 137.0 - 138.0 MHz -- Coordinated Use of Frequencies Among Spacecraft That Will be Operated to Mutually Visible Ground Stations
  - Channels are Typically Similar Bandwidths and PFDs
  - MSS is Secondary in 35% of the Band
- 148.0 - 149.9 MHz -- Mobile Earth Stations Have Channels Assigned Dynamically to Eliminate Contention With Other Active Users
- 148.0 - 149.9 MHz -- Coordinated Locations of Gateway Earth Stations to Ensure Adequate Separation From Existing Fixed and Mobile Receivers

ORBCOMM Proposed Downlink Channelization

Orbital Communications Corporation

An OSC Company



Existing TIROS/ METEOR Usage

MSS is Secondary to METSAT/SPACE OPERATIONS

Dynamic Channel Activity Assignment System (DCAAS)

Orbital Communications Corporation
An CSC Company

- Each Satellite has a Band Scanning Receiver
  - Measures Received Power in a 3 KHz Filter
  - Step Size is 2.5 KHz
  - Scan Time is 5 Seconds
- Each Measurement is Processed in a Weighted Average
  - Filtered for Short Term Statistics [Talker Activity], and
  - Long Term Statistics [Calling Activity]
- Current Set of Operating Channels is Selected from Those with Filtered Power Below a Suitable Threshold
- Changes to the Selected List are Implemented as Soon as Possible
- Satellites in Adjacent Planes Have Orthogonal Ordered Lists
  - Channels Below Threshold are put in Service in This Order
  - Minimizes Concurrent Use by Overlapping Satellites

Derivation of Interference Power Distribution

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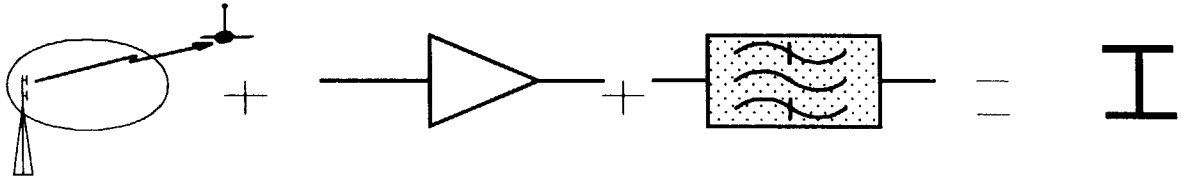
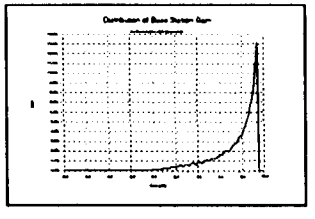
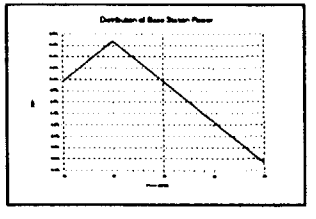
An OSC Company

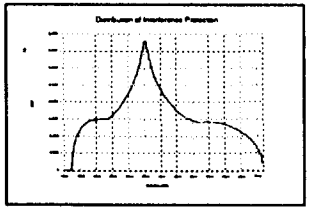




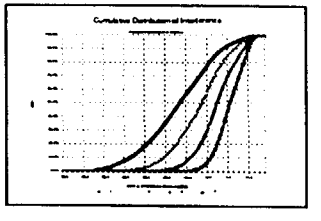
Antenna Gain Towards LEO MSS Space Station



Transmitter Power



Isolation to MSS Demod Filter



Interference Power Distribution for 1 or more active Emitters Pix(p)

Derivation of Dynmanic Channel Assignment Performance

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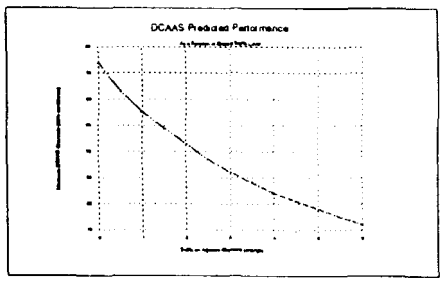
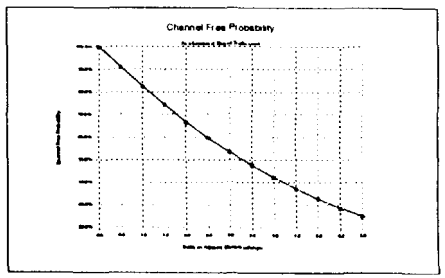
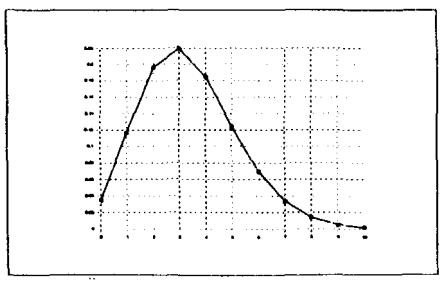
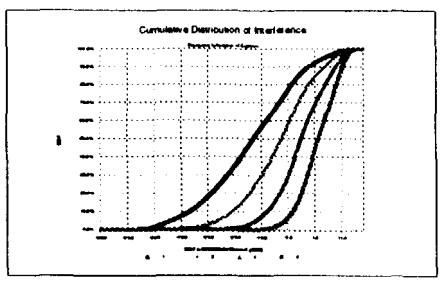
$$P(\geq n \text{ out of } M) = \sum_{i=n}^{M} P_{cf}^{i} \cdot (1 - p_{cf})^{(M-1)}$$



$$P_{cf} = \sum_{I=0}^{\infty} \frac{\theta^{-\lambda} \cdot \lambda^{x}}{x!} \int_{0}^{\tau} P_{ix}(y)\, dy$$







78.dcs

User Characteristics Make 148.0 - 149.9 MHz Sharing Possible

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- LEO MSS Service is Most Needed in Unserved Remote Areas
- Many Transmissions Will be Very Short
- Space Station Receiver is Protected by Dynamic Channel Assignment
- Terrestrial Users Operate, For the Most Part, Well Above Equipment Minimum Sensitivity
- Terrestrial Service Transmitters are Similar or Greater EIRP Density
  - These Transmitters Will Cause Interference to MSS, thus
  - Dynamic Assignment Must Avoid Operational Terrestrial Frequencies

74.dcs

Calculation Methodology For Evaluating Interference Potential From FDMA LEO MSS

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- Draft Recommendation on Calculation Methodology Reviewed at CCIR WP/8D, December 1991; Expected to be Finalized at Next 8D Meeting

- Calculation is of the Percentage of Time a Certain PFD Would be Exceeded at a Fixed Station or Base Station in the Mobile Service

- Methodology as Defined:
  - Shows Exceedance Levels to be Acceptable
  - Is Conservative -- No Advantage From Dynamic Assignment Assumed, Exceeding PFD is Assumed to Always Cause Interference

- Sharing Between MSS and Fixed and Mobile is Possible Without Unduly Restrictive Transmission Duration Technical Limitations In Part 2 of the FCC Rules

Worst Case Interference Probability as a Function of Share of Satellite Traffic in Mobile Service Area

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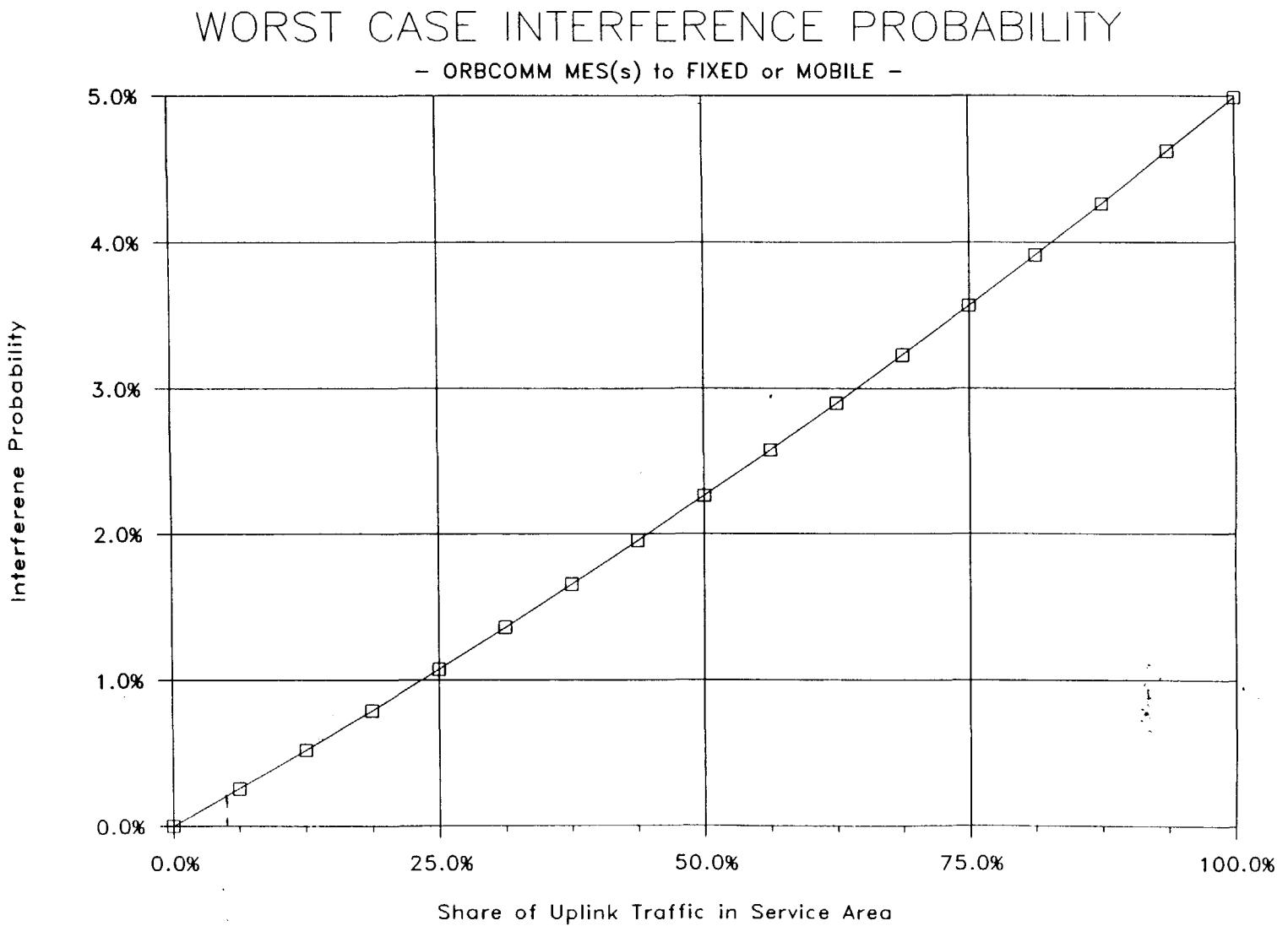

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Summary of FDMA Sharing Techniques Applicable to LEO MSS Systems

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- 137.0 - 138.0 MHz -- Coordination is Feasible Between Existing and Advanced Published Systems. Additional Channels Remain for Future Systems (LEOAS-15)

- 148.0 - 149.9 MHz -- Mobile Earth Stations Will Employ Operational Techniques to Avoid Active Terrestial User Channels, Eliminating Harmful Interference
  - Total Sharing Potential Driven by Terrestrial Transmitter Activity
  - Future Systems are Compatible With this Technique

- 148.0 - 149.9 MHz -- Gateway Earth Stations Will be Coordinated on a Case-by-Case Basis with Existing Terrestrial Systems. A need for 8-12 Stations has Been Identified Among All Proponents

VITASAT

INTERNATIONAL NON-VOICE, NON- GEOSTATIONARY SATELLITE SERVICE < 1 GHz

Presentation to the Below 1 GHz Negotiated Rulemaking Committee
August 24, 1992

VITASAT

GENERAL CHARACTERISTICS

- International
- Non-Commercial
  - Development
  - Humanitarian Purposes
- Experimental system in place (DCE - 1984; PCE - 1990)
- Two-LEO system - 1000 earth stations

SHARING AND COORDINATION

LIMITED SPECTRUM **NOW** (possibly more available in future)

- CURRENT USERS - U.S. GOVERNMENT
- CURRENT APPLICANTS (Orbcomm, Starsys, VITA)*
- *FUTURE APPLICANTS*

* Pending FCC determination

VITASAT

"NEGOTIATING" PROCESS

- Share & coordinate with *either* of current applicants plus users
- Meetings w. Orbcomm & Starsys
- Meetings with government users and applicants
- Engineering studies
- Meetings with regulating bodies - FCC & NTIA
- Share & Coordinate with *both* applicants and current users

PROPOSED NON-VOICE, NON-GEOSTATIONARY SATELLITE SERVICE

RESULTS (pending)

Applicants will share with current users

- 137 - 138 MHz
- 148 - 149.9 MHz
- 400.15 - 401 MHz

VITASAT will use

- 90 KHz FDMA **Uplink** in 148 - 149.9 MHz Band
- 90 KHz* FDMA **Downlink** in 400.15 - 401 MHz Band

* reduced from 100 KHz - Air Force/Starsys